

### Arrangement for closing roll nips

The invention relates to an arrangement according to claim 1 for closing roll nips in a multi-nip calender.

- 5 In a multi-roll calender (in the following also multi-nip calender) there often are as many as 10 – 12 rolls, which are located in the same or a different set of rolls in the same or a different frame so that one set of rolls always has 3 – 12 rolls. Each set of rolls has a first roll and a last roll, and one or more intermediate rolls between these rolls. In a set of rolls, a roll nip is always left between two adjacent rolls, in which 10 roll nip the surface of the fibre web is profiled in a desired way. In a multi-roll calender, the roll nip is generally formed between the roll with an elastic surface, such as a polymer-coated roll, and a heated, smooth-surfaced steel roll or cast iron roll. For calendering both sides of the fibre web in the same way, the multi-roll calender often has a so-called reverse nip, which is a roll nip formed between two similar 15 rolls, such as, for example, between two polymer-coated rolls. The one-sidedness of the fibre web can also be controlled so that, instead of the reverse nip, the calender is divided into two different sets of rolls. In a usual supercalender, in which the plane of the set of rolls is located substantially vertically in relation to the floor plane, the uppermost and the lowermost roll are variable crown rolls with chilled 20 surfaces, in other words rolls, in which the deflection caused by their own weight has been compensated by internal loading elements of the roll. The intermediate rolls are alternately rolls with chilled surface, heated by water, and paper- or polymer-coated rolls; nowadays, most often polymer-coated rolls. The linear pressure in roll nips grows when transferring from the upper nip to the lower nip, due to earth 25 gravity, and the linear loads of the roll nips depend on the specific weight of the rolls. The linear loads transverse to the machine direction of the roll nips, i.e. the linear loading profile also often has deflections, due to the load forces influencing the axle journals at the ends of the intermediate rolls, caused by auxiliary means, such as bearing houses and steam boxes.
- 30 In the so-called Optiload multi-roll calendering (multi-nip calendering) developed by the applicant, the own weight of the intermediate rolls has been lightened so that the axle journals are attached to loading arms; each intermediate roll is attached to loading arms from the bearing houses, the loading arms being again attached to the calender frame. With the loading arms it is possible to direct roll-lifting forces of 35 different sizes to the ends of the roll and thus to compensate to a desired extent the

influence caused by the own weight of the roll and the auxiliary means, loading the roll nips and thus increasing the linear loads of the roll nips. In this calendering method, also the deflections caused by the auxiliary means at the ends of the rolls have been compensated in the linear loading profiles transverse to the machine direction of the roll nips. The intermediate rolls have further been selected so that they have almost the same specific deflection caused by earth gravity. In this kind of calendering method, it is possible to use substantially the same linear pressure in all roll nips, i.e. the linear load distribution of the roll nips is uniform. Of the present calendering methods, this calendering method has the largest calendering window, i.e. with this method, it is possible to calender almost all paper qualities with high speeds while keeping the profiling quality of the paper good.

In the so-called Optiload method disclosed above, the lowermost roll is arranged to move on guide tracks in the calender frame, and the calendering is initiated by closing the roll nips above the lower roll by lifting the lowermost roll upwards in the plane of the intermediate rolls using hydraulic cylinders attached to the bearing houses. The additional load to the roll nips is brought either from above or below, for example, by loading the uppermost or lowermost roll with the additional load.

The principal object of the invention is to eliminate the drawbacks in the state-of-the-art technology. Thus, the object of the invention is to provide a method for closing the roll nips in a set of rolls, in which it is possible to replace the heavy hydraulic cylinders connected to the lower roll with a lighter arrangement. It is also the object of the invention to provide a method, in which the control of the linear loads of the roll nips and the control of the roll loads in a set of rolls stays good, irrespective of the changed closing method of the roll nips.

The above-mentioned objects are achieved by an arrangement according to claim 1 for closing the roll nips in a multi-roll calender (multi-nip calender).

In the arrangement of the invention, the multi-roll calender (multi-nip calender) consists of one set or several sets of rolls attached to one frame or several frames. Each set of rolls has at least three rolls, and at least the first roll and the last roll in the set of rolls is provided with equipment, with which their casing can be transferred in the direction of the plane of the set of rolls towards the intermediate rolls in the set of rolls. In the arrangement, the first roll and the last roll in the set of rolls are fixedly attached, and further, at least one of the intermediate rolls in the set of rolls is fixedly attached. The other intermediate rolls are preferably provided with equipment for lightening the own weight of the intermediate rolls and/or the auxil-

iary means related to the intermediate rolls. In this case, the roll nips in the set of rolls are closed so that the roll nips of the rolls between the first roll and the fixedly attached intermediate roll are closed by moving the first roll in the set of rolls in the direction of the plane parallel to the set of rolls towards the intermediate rolls, and

5 the roll nips between the last roll and the fixedly attached intermediate roll are closed by moving the last roll in the set of rolls in the direction of the plane parallel to the set of rolls towards the intermediate rolls.

In this application, the direction of the plane of the set of rolls refers to the direction of the plane drawn through the centre line of the rolls in the set of rolls.

10 In the arrangement disclosed above, there is no need for heavy hydraulic cylinders for lifting the last roll in the set of rolls, i.e. often the lowermost roll as the roll nips are closed, because the first roll and the last roll (or upper roll and lower roll, if the set of rolls is in a vertical position in relation to the floor plane) are fixedly attached to the frame or some other fixed structural element, and the roll nips are closed by

15 moving the casing of the first roll and the last roll towards the intermediate rolls.

In an advantageous embodiment of the invention, the linear load distribution of the roll nips in the set of rolls is adjusted by bringing an additional load to the first and/or last roll in the set of rolls, which generates the linear load to the roll nips in the set of rolls. As distinct from the conventional multi-roll calendars, the additional

20 load does not influence the linear load distribution of the roll nips in a uniform or linear way, but the extent of the load in a certain roll nip depends on whether the roll nip in question is located before the fixedly attached intermediate roll or after the intermediate roll as the set of rolls is looked at from the direction of the influencing force. Thus, the additional load of the first roll has a substantially smaller effect on

25 the linear loads of the intermediate rolls between the fixedly attached intermediate roll and the last roll than on the linear loads of the roll nips of the intermediate rolls between the attached intermediate roll and the first roll. The additional load of the last roll again has a substantially smaller effect on the linear loads of the roll nips between the fixedly attached intermediate roll and the first roll than on the linear

30 loads of the roll nips between the fixedly attached intermediate roll and the last roll.

Thus, a considerable difference is achieved by the fixedly attached intermediate roll to the linear load distributions of the roll nips located on different sides of the intermediate roll in question. In this case, the fixedly attached intermediate roll provides the considerable advantage that there are more means than usual to adjust the linear load distribution of the roll nips and that more possibilities are obtained to adjust the

calendering potential of the calender, with which it is possible to adjust, among others, the profiling result of both sides of the fibre web in a more exact manner than before.

The invention is next described in more detail by referring to the enclosed drawings,  
5 in which

Figure 1 is a schematic view of a multi-roll calender seen directly towards the end of the set of rolls as the roll nips are being closed;

10 Figure 2 is a schematic view of the development of the linear load distribution of the set of rolls in Figure 1 in roll nips located on different sides of the fixedly attached intermediate roll, seen from the front;

Figure 3A is a schematic view of a multi-roll calender with two sets of rolls in the same frame, seen directly towards the end;

Figure 3B is a schematic view of a multi-roll calender with two sets of rolls in two different frames, seen directly towards the end.

15 The main structures of the Figures and which part of the invention the Figures are meant to illustrate, are first gone through.

Figure 1 illustrates the vertical multi-roll calender 1 (= multi-nip calender) arranged to the same calender frame, with five intermediate rolls 4. Of the intermediate rolls, the middlemost one is attached to the calender frame 7, and the other intermediate  
20 rolls are provided with lightening equipment for compensating their own gravity. The uppermost and lowermost roll 3 of the calender are attached to the calender frame. In the situation according to the Figure, the calendering of the fibre web W is initiated, and the roll nips N are closed.

Figure 2 illustrates the development of the linear load distribution of the roll nips N on different sides of the attached intermediate roll in a multi-roll calender of the invention, the set of rolls 2 of which is similar to the one shown in Figure 1. The set of rolls 2 is shown as a simplified diagram for illustrating the loads. The Figure illustrates the linear pressure generated by the additional load in the roll nips N; Nb1, Nb2 on different sides of the intermediate roll 4; 43, and the development of the linear load distribution in the roll nips N of the set of rolls.  
30

Figure 3A illustrates an advantageous embodiment of the invention, in which the multi-roll calender has two sets of rolls 2. Both parts of the set of rolls are attached

to the same calender frame. Both parts of the set of rolls have the first roll and the last roll 3 (the upper and lower roll), which are fixedly attached to the frame, and there are three intermediate rolls 4 between them. Of the intermediate rolls, the two outermost ones 4; 41, 43 are attached to the loading arms and the middlemost one is  
5 fixedly attached to the calender frame. The calender frame and the attachment of the rolls to the frame and the loading arms are left out of the Figure for simplifying the Figure. These structures are similar to the ones in Figure 1.

Figure 3B illustrates a second advantageous embodiment of the invention, in which the set of rolls has two parts of the set of rolls. Both parts of the set of rolls are similar to the ones in Figure 3A, but they are attached to different frames. Figure 3B has  
10 been simplified in a similar manner as Figure 3A.

The multi-roll calender 1 according to Figure 1 has the upper roll 3; 31 and the lower roll 3; 32, and five intermediate rolls 4; 41, 42, 43, 44, 45. The upper and lower rolls are shown as a partial cross-sectional figure for illustrating the load equipment 31a and 32a inside them. In addition, the calender 1 includes take-off rolls 6, with which the fibre web arriving from the previous roll is detached from the roll surface before the fibre web is fed to the next roll nip. The uppermost roll and the lowermost roll are so-called Sym rolls, which have the loading devices 3; 31, 32;  
15 31a, 32a inside the rolls. With the loading devices 31a, 32a it is possible to compensate deviations caused by the own weight of the upper and lower roll 3, but with the help of these it is also possible to close the roll nips N of the calender and to generate the desired load to the said roll nips. The loading devices 31a, 32a consist of three shoe element lines, each of which is attached to the fixed axle frame (not shown in the Figure). Each shoe element line has several separate shoe elements,  
20 25 which can be loaded through hydraulic liquid channels leading to them (not shown in the Figures). On top of the shoe elements there is a flexible, polymer-coated roll casing 31b, 32b, which can be rotated on top of the shoe elements. The structure of such a so-called shoe roll is conventional in itself, and it has been disclosed, for example, in the own patent application of the applicant, so its structure is not described  
30 in more detail in this connection.

The uppermost roll 3; 31 and the lowermost roll 3; 32 (or the first and last roll) are attached directly to the calender frame 7 by suitable fastening elements 31c, 32c.

Between the uppermost and the lowermost rolls there are five intermediate rolls 4, of which the middlemost intermediate roll 4; 42 is likewise attached directly to the  
35 calender frame 7 in a similar way as the uppermost and the lowermost rolls. The

outermost intermediate rolls, i.e. the first intermediate roll 4; 41 and the fifth intermediate roll 4; 45, seen from the first, i.e. the uppermost roll 3; 31 of the set of rolls, are heated chill rolls. The said outermost intermediate rolls 4; 41, 45 are hard-surfaced rolls, which are rotatably pivoted to the bearing houses 41a, 45a from their ends. The intermediate rolls between the outermost intermediate rolls 41, 45 and the fixedly attached intermediate roll 43, i.e. the second intermediate roll 4; 42 and the fourth intermediate roll 4; 44 are flexible-surfaced polymer-coated rolls. The middlemost intermediate roll is fixedly attached to the calender frame in a similar way as the uppermost and the lowermost roll. The middlemost intermediate roll is a smooth-surfaced metal roll. The intermediate rolls 41, 42, 44 and 45 are provided with loading arms 5a used as lightening elements 5 (shown more exactly only at the place of the intermediate roll 4; 41, because the load lightening elements of the said intermediate rolls are identical), which are attached to the bearing houses 41a-45a of the said intermediate rolls. The loading arms 5a are pivotably joined to the calender frame 7 by axially directed joints. The loading arms 5a are provided with lightening elements, such as piston-cylinder elements 5b. The lightening elements 5 are used for compensating the deflections caused by the own weight of the rolls in question in the linear loading profiles transverse to the machine direction of the roll nips. The structure of the loading arms 5a is conventional in itself and, for example, the applicant's own patent FI 96334 is referred to with regard to their more detailed structure. The diameters and weights of the intermediate rolls 4 have been chosen so that their natural specific deflection is substantially the same. In Figure 1, the calendering of the fibre web W is initiated, and the roll nips N are closed. The roll nips N are closed by loading the internal loading devices 31a, 32a of the upper and lower roll 3; 31, 32. The loading devices 31a, 32a are loaded by directing hydraulic liquid to the shoe elements so that the hydraulic liquid forms a lubricating liquid layer between the shoe elements and the casings of the upper and lower rolls rotating on them. As the shoe elements of the lower roll and the upper roll are loaded, the casing of the said rolls extends outwards. In the figure, the location of the casings 31b' and 32b' of the rolls 31, 32 is shown by a broken line in a case, in which the shoe elements are not being loaded, and the location of the roll casings 31b, 32b is shown by a solid line in a case, in which the shoe elements are being loaded. Upon extending, the casing 32b of the lower roll pushes close the roll nips N; Na2, Nb2 and Nc2 above it. Respectively, the casing 31b of the upper roll pushes close the roll nips N; Na1, Nb1 and Nc2 below it, as it extends. By loading the shoe elements of the upper and lower roll with a desired force, a linear pressure of about 0-500 kN can be generated to the roll nips N.

Figure 2 presents the development of the linear load distribution of the roll nips N in the set of rolls 2 as loads are directed to the intermediate rolls 4 on the lower roll 3; 32. For facilitating the observation it is assumed that the own gravity of the intermediate rolls and the load caused by the auxiliary means related to the intermediate rolls 4; 4; 41, 42, 43 and 44 is completely lightened. The set of rolls 2 is similar to the one shown in Figure 1 so that the intermediate roll 43 is fixedly attached to the calender frame. In the Figure it is shown how the additional load F1 brought to the lowermost roll causes the linear load F2 in the roll nip N; Nc2 facing the lowermost roll of the fixedly attached intermediate roll, and the additional load F3 in the roll nip N; Nc1 on the other side of the intermediate roll. The additional load F1 and the loads F2 and F3 are marked approximately to the middle point of the lower roll and the roll nips as resultant forces; in fact, the load forces in question are distributed to the length of the whole lower roll and the roll nips Nc1 and Nc2. The linear load F2 achieved by the additional load F1 in the roll nip Nc2 between the fixed intermediate roll 32 and the intermediate roll 44 is considerably bigger than the linear load F3 in the roll nip Nc1 between the fixed intermediate roll 43 and the intermediate roll 42, due to the rigid fastening of the intermediate roll 4; 43. The additional load F1 could as well be brought to the upper roll 31, in which case the additional load would cause a linear load in the roll nip Nc1 between the fixedly attached intermediate roll 43 and the intermediate roll 42, respectively, which would be considerably bigger than the linear load in the roll nip Nc2 between the fixed intermediate roll 43 and the intermediate roll 44. The additional load can be brought to the lower/upper roll either by internal loading devices of the said upper and lower rolls 3; 31, 32, with which the deflections usually caused by the gravity of the said rolls are compensated or, alternatively, the load can be brought to the said rolls using an outside force, such as a roll outside the set of rolls, with which, for example, the lower roll 32 would be pressed towards the intermediate rolls 4 in the direction of the set of rolls. The direction of the plane of the set of rolls is the same as the direction of the plane drawn through the central line of the rolls in the set of rolls.

Figure 2 also shows the nip load distribution achieved by the additional load F1 brought to the lower roll 3; 32. The nip load directed to a certain roll nip N is drawn to continue always over the entire roll for illustrating the loads, although the nip pressure influencing in a certain roll nip would not continue in a similar way in the roll itself. From the diagram in the Figure it can be seen that a bigger linear load can be achieved to the roll nips between the lower roll 32 and the fixedly attached intermediate roll 43, i.e. the roll nips Na2, Nb2, Nc2 by the additional load F1 than to the roll nips Na1, Nb1 and Nc1 located after the fixedly attached intermediate roll 4;

43, as the set of rolls 2 is observed from the influencing direction of the force (load) F1. Because the load coming from the first side of the fixedly attached intermediate roll 4; 43 decreases considerably when transferring from the roll nip on the first side of the said intermediate roll to the roll nip on the opposite side of this intermediate 5 roll, it is possible to considerably influence the linear load distribution of the roll nips with the fixed intermediate roll and to then adjust the profiling of both sides of the fibre web in a more exact manner than before.

The multi-roll calender shown in Figure 3A consists of two sets of rolls 2 attached to the same frame, with a so-called reverse nip between them. The sets of rolls are 10 identical and for illustrating this, their parts are indicated by the same numbers. Both sets of rolls 2; 21 and 2; 22 consist of upper and lower rolls 31, 32 fixedly attached to the frame, and of three intermediate rolls 4, the middlemost 42 intermediate roll of which is fixedly attached to the frame. The outermost intermediate rolls 41 and 43 are polymer-coated elastic rolls, and the intermediate roll 43 attached to the 15 frame is a heated smooth-surfaced chill roll. The outermost intermediate rolls are suspended to the frame from their bearing houses by loading arms in a similar way as is shown in the example 1 in connection of the intermediate rolls 41, 42, 44 and 45. The upper roll 31 and the lower roll 32 are heated smooth-surfaced chill rolls and they have internal loading devices for the said rolls. The structure of the loading 20 devices is similar to the one shown in Example 1, in which the structure of the upper and lower rolls is described. The path of the fibre web W in the roll nips is shown by arrows with closed ends; for simplifying the figure, the take-off rolls are not shown in the figure. The last roll 3; 32 of the first set of rolls 2; 21 and the first roll 3; 31 of the second set of rolls 2; 22 are smooth-surfaced chill rolls so that a so-called re- 25 verse nip is formed to the set of rolls in which case it is possible to control the profiling of both sides of the fibre web with the set of rolls.

The sets of rolls 2 of the multi-roll calender shown in Figure 3B and the markings of their parts are similar to those in Figure 3A, but the sets of rolls are now arranged to different frames so that the fibre web W is brought from one set to the other in air.

30 It is obvious for one skilled in the art that it is possible to realize the invention in many other ways in addition to the embodiments disclosed in the examples above.

Thus, even if one set of rolls in the multi-roll calender (multi-nip calender) according to the invention preferably has a relatively small number of rolls, in some cases there may be as many as 10 – 15 rolls in each set of rolls. In the sets of rolls de- 35 scribed above, the uppermost and the lowermost roll are so-called sym rolls, in

which pressure elements containing several different pressurising zones are used for loading the casing of the roll. However, it is fully possible to replace the above-mentioned internal loading devices of the rolls with other loading devices known from the state of the art, with which the casing of the lower and/or upper roll can be moved to the direction of the intermediate rolls in a plane defined by the set of rolls.

5 Likewise, in the examples disclosed above, the sets of rolls are located substantially in an angle of 90 degrees in relation to the horizontal plane. However, the angle of the plane of the set of rolls in relation to the horizontal plane has no significance as such, and by placing a multi-roll calender or part of its rolls, for example, to the

10 horizontal plane or to some other angle between 0 and 90 degrees, a part of the own gravity of the intermediate rolls or all of it can be left uncompensated. If the own gravity of the intermediate rolls need not be compensated, equipment for lightening the own weight of the intermediate rolls is not necessarily needed in these intermediate rolls, either.

15 In the examples disclosed above, the first and last roll in the set of rolls and the fixedly attached intermediate roll are attached to the (calender) frame. However, it is also entirely possible to attach the said rolls to other structures in a paper or cardboard machine or to a support located on the floor.

**Reference numbers of the main parts of the figures**

<b>Calender</b>	<b>1</b>
<b>Set of rolls</b>	<b>2</b>
<b>First or last roll</b>	<b>3</b>
<b>5 Intermediate rolls</b>	<b>4</b>
<b>Lightening element</b>	<b>5</b>
<b>Take-off roll</b>	<b>6</b>
<b>Frame</b>	<b>7</b>
<b>Fibre web</b>	<b>W</b>
<b>10 Roll nip</b>	<b>Na, Nb, Nc</b>

In other parts, a numbering mode has been followed, in which the first number of the part informs to which main part the said part is connected.